SOLAR AND NET RADIATION AT PALMER, ALASKA 1960--71

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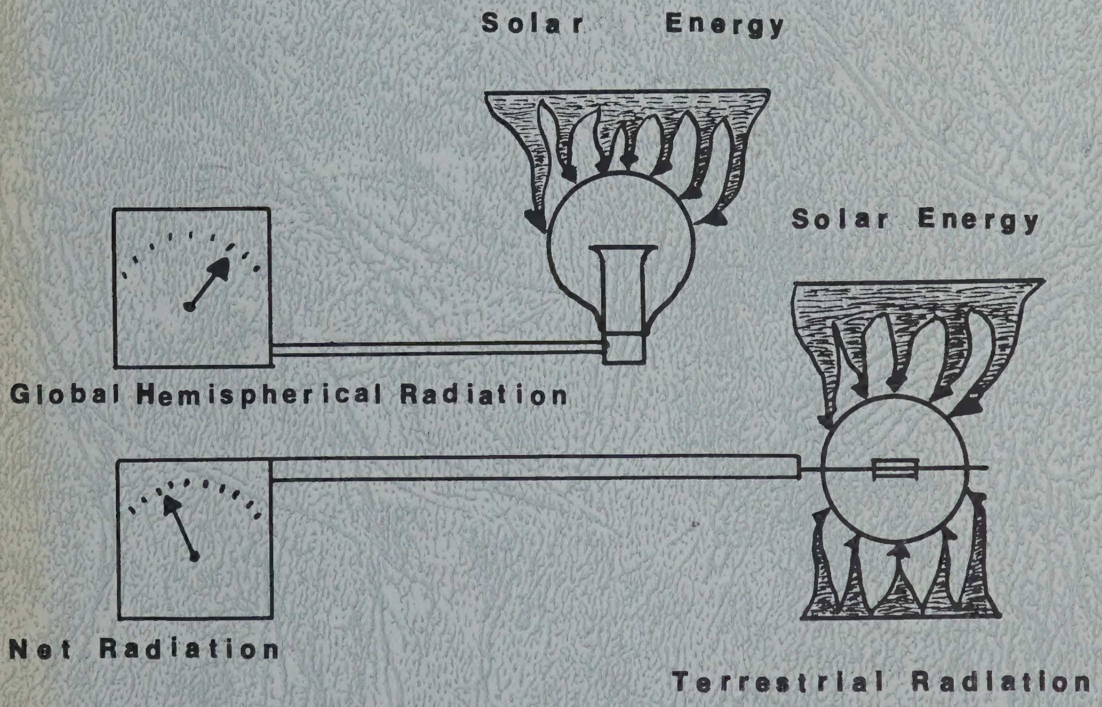

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Solar and net radiation received at Palmer, Alaska (61° 36' N. lat., 149° 06' W. long.) have been observed for more than ten years. On a yearly basis, the daily average incoming global short wave radiation has been 219.1 langleys, and net radiation has been 70.0 langleys.

From May 3 thru August 1, net radiation averages 221.2 langleys. This is 2.571 kilowatt hours per square meter, or 815.2 Btu per square foot (English units).

From November 1 thru January 30, net radiation is negative, showing an energy loss of 54.2 langleys per day. This is equivalent to 0.630 kilowatt hours per square meter or 199.8 Btu per square foot.

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1960-71

Solar radiation which falls upon the surface of the earth exerts a powerful influence upon many physical and biological processes. It provides the energy both for photosynthesis and atmospheric circulation. Crabb (1952) states, in discussing hydrologic relationships, that the amount and intensity of radiant solar energy is known to have a marked effect on losses of soil moisture by evaporation. This radiation is also related to evapotranspiration (Mielke and Peck, 1967), and to soil temperatures (McWhorter and Brooks, 1965).

The annual peak of solar radiation generally occurs about one month before the peak of air temperatures (Peck, et al., 1968). The distribution and variation of solar energy at different times of the year are important in all areas of the world, but are particularly important in high latitudes where energy is in short supply.

Solar radiation is highly concentrated in the visible and short infra-red wave lengths. Its measurement gives an incomplete picture of the total energy flux. Net radiation, the difference between the incoming and outgoing components of radiant energy, has become recognized as an important meteorological parameter. Net radiation will be positive (incoming component greater than the outgoing component) on a sunny day and negative (outgoing component greater than the incoming component) on a clear night. For a 24-hour period it is usually positive in the warm season, and in areas of high latitudes is negative during the cold season. At Palmer, Alaska, both solar and net radiation have been measured over a period of eleven years.

Instrumentation and Data Handling

The incident solar radiation on a horizontal surface was first measured at Palmer with a 10-junction Eppley pyranometer starting June 13, 1960. On February 19, 1962 a new but similar instrument was installed; this was replaced on April 25, 1962 with a more sensitive Eppley unit. On November 23, 1966, a 50-Junction Eppley was obtained and since that date it has been used for winter conditions and the 10-Junction unit for warm season measurements.

The original net radiation instrument, a Beckman and Whitley radiometer, was installed June 13, 1960. Data from a Funk net radiometer installed October 19, 1964, were used for the remaining record. On December 9, 1969, a new sensor was installed on the Funk radiometer. The plastic domes on the radiometer have been replaced as necessary.

Originally the data were recorded on strip charts and the daily totals obtained by hand integration. On October 19, 1965, automatic integrators were installed. The data are still recorded on strip charts as a back-up source in case of integrator malfunction and to provide a record of the daily pattern of radiation.

Results and Discussion

The average daily solar and net radiation in langleys per day for each week of record, and the weekly average for the eleven year period, are presented in Tables 1 and 2. Data were summarized by climatological weeks. The data for the interval February 21-28 or 29, were all included in the last week of the climatological year.

Dale (1956) reported that the June and July, 1954 records of the Matanuska Experiment Station showed solar radiation roughly comparable to stations in the northwestern and northeastern United States. This was an exceptionally high radiation period. The 11-year record summarized here shows that individual days can reach quite high radiation levels, but that on the average, solar radiation is lower here than for stations in

any of the 49 more southern states.

Data summarized by Lof et al., (1966) indicates that the 2-year record of Goose Bay, Labrador is the closest to that of Palmer of all the stations in the U.S. and Canada having available records. Seattle records for solar radiation during May and June are only slightly higher than those at Palmer but for July and August their records exceed those of Palmer three out of four years.

A similar relationship exists between Palmer, Alaska and Caribou, Maine. The cloudiness that usually occurs during July-August at Palmer results in a reduction of radiation for this period.

Net radiation reaches an average maximum of about 250 langleys per day in mid-June. Positive values are usually obtained from March 15 to October 12 and negative values for the rest of the year. The daily mean values for each week appear in Table 2.

Figure 1 shows graphically the average amount of incoming short wave energy (insolation) and the extent and direction of the net radiation. The large range of diurnal variability in incoming short wave energy is illustrated by the intervals between the probability curves at the 10 percent and 25 percent "chance" of receiving greater or lesser amounts shown on Figure 1. Solar energy received on a horizontal surface at various locations in the United States is shown on Table 3. Palmer and Fairbanks, Alaska receive the lowest amounts of insolation of any locations shown in the tables during the months of October, November, December, January, and February, due primarily to the positions of high latitude.

Energy from the sun is continuous in supply and free except for the cost of interception and utilization. Planning for its use requires an estimate of the variability and minimum levels of anticipated energy flux. These data provide such information for a period of eleven years at Palmer, Alaska.

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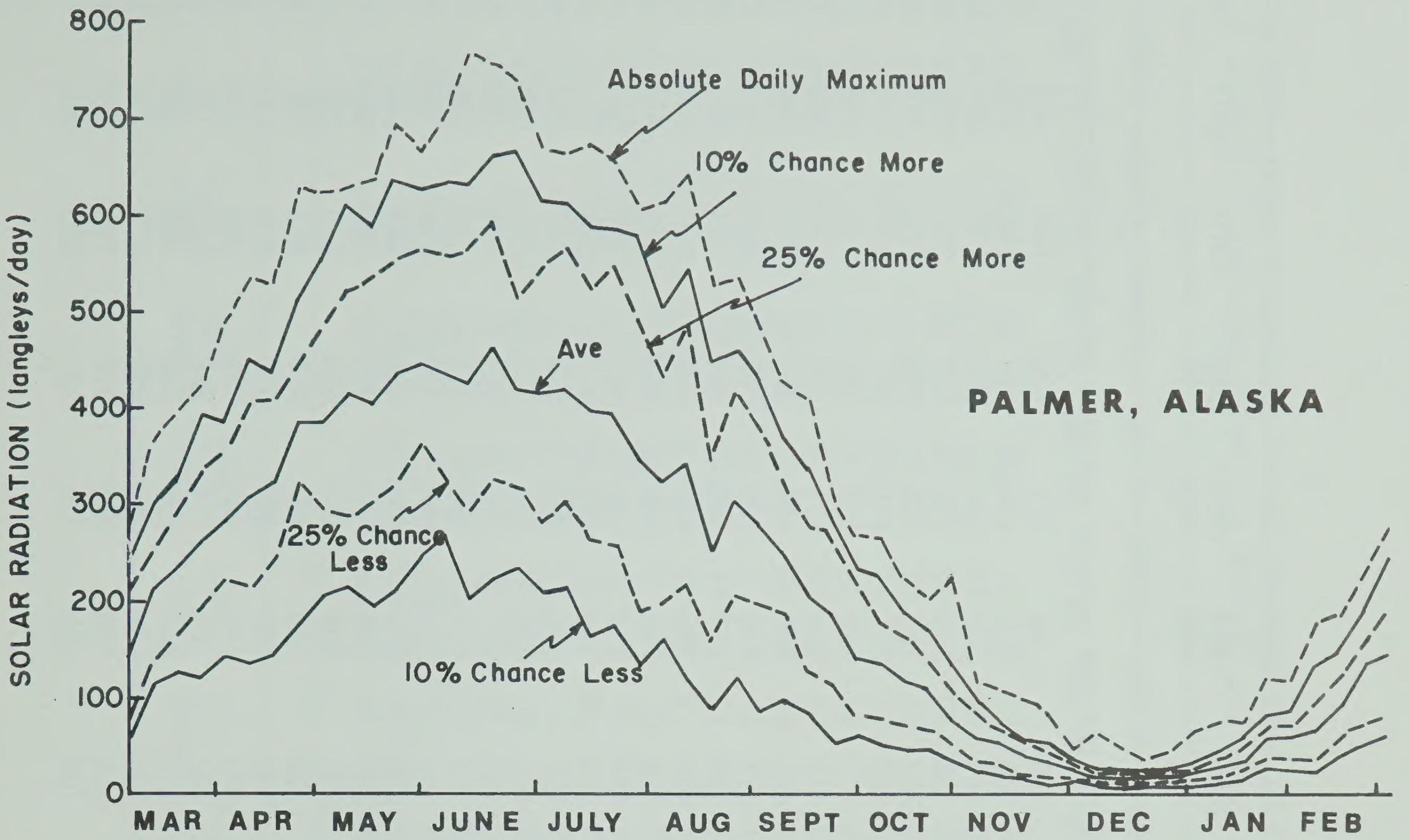
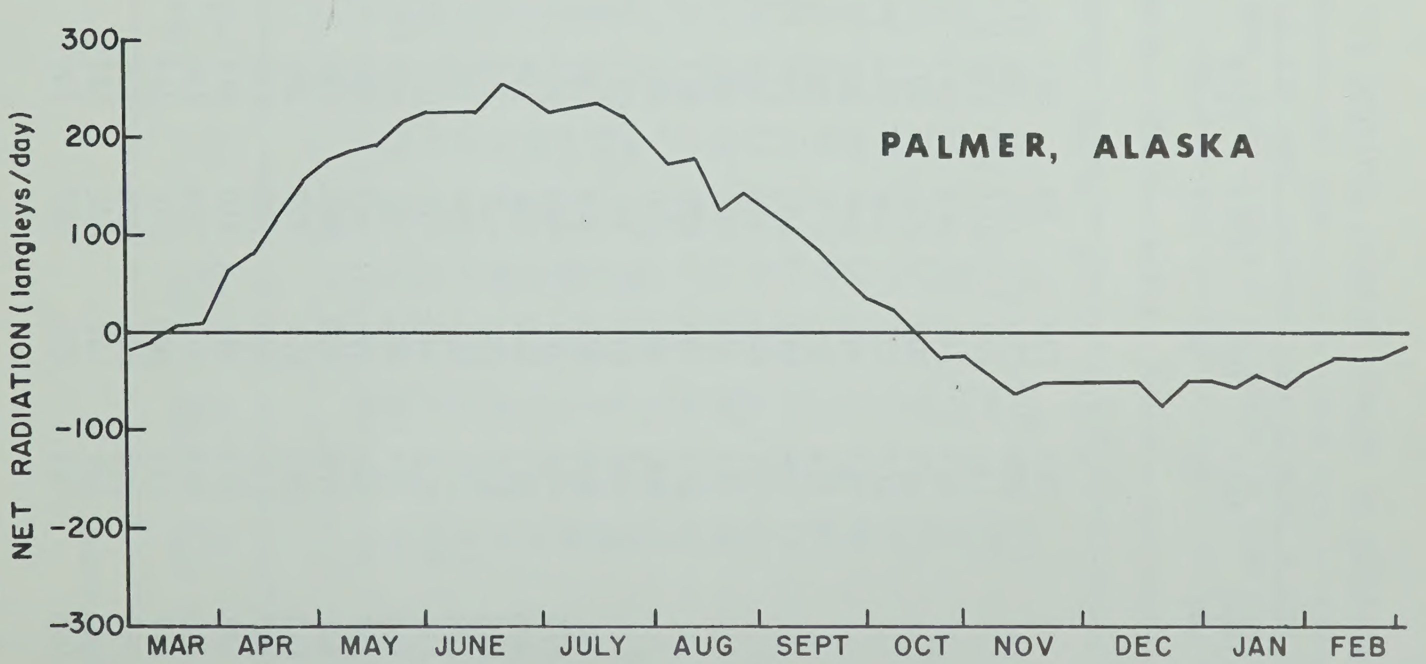


PATTERN OF GLOBAL HEMISPHERICAL RADIATION



NET RADIATION – MEAN, June 1960 – 1971

Figure 1

Table 1. SOLAR RADIATION AT PALMER, ALASKA, LATITUDE 61° 36' N.

Period[1]	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70	1970-71	1971	Av.
	langleys per day												
Mar 1-7	-	223	196	83	121	71	189	94	121	170	134	163	142
Mar 8-14	-	300	250	137	266	147	225	222	234	197	192	188	214
Mar 15-21	-	239	277	257	280	167	241	233	226	210	175	254	233
Mar 22-28	-	371	341	268	251	129	196	286	252	247	264	297	264
Mar 29-Apr 4	-	327	309	378	301	208	231	183	298	286	264	314	282
Apr 5-11	-	267	421	326	313	219	387	215	338	262	331	312	308
Apr 12-18	-	313	348	344	290	421	273	318	395	365	256	245	324
Apr 19-25	-	354	525	277	292	369	418	458	415	416	340	364	384
Apr 26-May 2	-	500	443	441	398	268	461	400	328	345	312	346	386
May 3-9	-	601	489	338	449	357	371	448	320	345	402	397	411
May 10-16	-	387	340	375	426	497	389	377	380	367	430	451	402
May 17-23	-	513	298	499	427	416	436	395	434	501	448	445	437
May 24-30	-	456	385	570	451	381	376	486	399	544	468	412	448
May 31-Jun 6	-	530	431	331	517	384	424	310	432	466	506	475	437
Jun 7-13	-	558	422	439	492	405	474	346	525	474	296	231	424
Jun 14-20	576	466	617	403	414	456	456	396	403	541	334	381	454
Jun 21-27	488	551	424	386	399	381	445	336	465	437	292	544	429
Jun 28-Jul 4	422	427	586	422	373	366	337	337	484	469	349	333	409
Jul 5-11	525	457	427	463	335	420	333	464	396	414	368	545	429
Jul 12-18	414	458	443	313	535	320	480	335	311	400	355	306	389
Jul 19-25	360	383	385	305	405	309	528	277	564	428	383	237	380
Jul 26-Aug 1	217	397	472	368	300	447	281	295	356	405	248	263	337
Aug 2-8	331	283	349	281	345	312	218	307	456	427	270	216	316
Aug 9-15	413	443	417	432	308	201	328	169	353	410	301	282	338
Aug 16-22	347	219	323	177	192	333	146	222	303	335	235	278	259
Aug 23-29	308	447	161	310	314	308	267	245	344	356	294	269	302
Aug 30-Sep 5	266	419	316	283	294	261	282	121	312	282	240	175	271
Sep 6-12	177	197	258	291	314	214	221	248	276	255	235	222	242
Sep 13-19	260	233	221	208	160	90	150	119	262	325	213	197	203
Sep 20-26	155	202	147	242	141	87	205	128	245	272	193	182	183
Sep 27-Oct 3	104	141	238	127	109	159	102	195	115	151	103	102	137

Table 1. (Continued)

Period[1]	1960 -61	1961 -62	1962 -63	1963 -64	1964 -65	1965 -66	1966 -67	1967 -68	1968 -69	1969 -70	1970 -71	Av.
	langleys per day											
Oct 4-10	151	200	196	112	72	92	99	168	134	124	122	134
Oct 11-17	166	138	95	87	100	133	78	124	100	151	77	114
Oct 18-24	126	90	83	92	84	118	105	101	113	155	126	108
Oct 25-31	117	73	69	81	75	73	68	55	101	96	53	78
Nov 1-7	71	47	68	49	61	94	31	33	66	84	41	59
Nov 8-14	61	46	59	50	41	44	62	29	43	83	41	51
Nov 15-21	46	27	28	54	12	41	41	13	33	62	34	38
Nov 22-28	52	41	46	33	29	17	19	26	24	31	22	31
Nov 29-Dec 5	32	17	26	18	19	23	26	23	22	22	27	23
Dec 6-12	25	15	15	9	17	10	23	9	22	28	11	17
Dec 13-19	32	15	7	13	12	10	7	12	14	18	8	13
Dec 20-26	27	26	8	15	15	15	13	15	20	20	9	17
Dec 27-Jan 2	25	16	18	14	19	21	11	7	26	22	18	18
Jan 3-9	41	17	19	21	19	18	19	18	22	25	18	22
Jan 10-16	49	20	15	20	17	25	33	28	36	36	31	28
Jan 17-23	40	42	20	44	22	22	44	27	38	44	47	35
Jan 24-30	83	50	61	43	54	48	55	42	54	49	64	55
Jan 31-Feb 6	63	61	79	34	43	56	55	62	54	55	43	55
Feb 7-13	97	100	50	83	37	62	83	38	73	58	50	66
Feb 14-20	126	85	105	115	113	90	84	64	97	87	54	93
Feb 21-28	169	200	142	91	111	133	123	71	144	73	98	123
Total		90,916	87,276	78,064	78,288	71,736	76,643	69,510	83,846	86,975	71,575	79,483
Av. per mo.		7,576	7,273	6,505	6,524	5,978	6,387	5,793	6,987	7,248	5,965	6,624

1 Calculations made on standard climatological weeks where March 1-7 is week 1. Period December 27-January 2 includes last 5 days of one calendar year and only 2 days of next calendar year. February 21-28 includes 8 days, except in leap years when 9 days are included.

Table 2. NET RADIATION AT PALMER, ALASKA, LATITUDE 61° 36' N.

Period	1960 -61	1961 -62	1962 -63	1963 -64	1964 -65	1965 -66	1966 -67	1967 -68	1968 -69	1969 -70	1970 -71	1971	Av.
	langleys per day												
Mar 1-7	-	-30	-15	19	16	5	-72	-3	10	-46	19	-75	-16
Mar 8-14	-	-7	13	23	-49	18	-44	-38	11	-13	40	-56	-9
Mar 15-21	-	29	-15	3	9	58	-46	36	4	13	49	-71	6
Mar 22-28	-	34	23	28	13	75	44	59	-36	30	58	-68	10
Mar 29-Apr 4	-	134	135	142	30	95	52	66	19	55	46	-13	69
Apr 5-11	-	117	155	88	129	89	115	38	-25	37	81	50	79
Apr 12-18	-	192	140	34	147	183	69	144	130	73	113	73	118
Apr 19-25	-	108	232	126	181	168	158	184	168	127	120	132	155
Apr 26-May 2	-	226	230	256	181	134	193	183	116	123	156	138	176
May 3-9	-	291	269	184	232	155	160	203	119	98	179	156	184
May 10-16	-	200	187	201	245	239	164	172	171	147	202	166	190
May 17-23	-	282	186	263	244	205	200	194	230	192	228	169	218
May 24-30	-	253	221	319	252	199	182	227	205	223	250	143	225
May 31-Jun 6	-	299	272	188	323	204	227	153	212	196	249	170	227
Jun 7-13	-	309	255	264	316	210	212	175	256	177	188	98	224
Jun 14-20	359	270	376	260	265	249	215	180	218	224	207	160	249
Jun 21-27	428	288	240	234	272	227	211	186	241	186	179	226	243
Jun 28-Jul 4	178	253	358	267	241	189	158	186	246	204	194	134	217
Jul 5-11	256	256	242	301	242	228	167	232	208	204	185	236	230
Jul 12-18	386	264	284	192	373	189	238	166	157	188	166	154	230
Jul 19-25	216	244	283	196	260	164	252	159	274	213	188	127	215
Jul 26-Aug 1	122	242	312	217	224	230	135	166	170	161	119	135	186
Aug 2-8	196	153	204	167	255	170	93	167	206	169	129	105	168
Aug 9-15	248	247	258	249	199	110	138	98	134	127	143	131	174
Aug 16-22	208	138	179	106	115	175	46	116	133	109	96	123	129
Aug 23-29	183	241	116	149	197	131	101	123	150	95	103	103	141
Aug 30-Sep 5	153	226	160	157	139	115	96	64	107	82	113	65	123
Sep 6-12	101	95	127	150	142	104	61	145	80	54	96	70	102
Sep 13-19	154	124	104	148	69	39	22	34	76	60	95	57	82
Sep 20-26	96	101	51	112	45	33	20	30	41	42	61	47	57
Sep 27-Oct 3	60	80	82	34	30	36	8	39	2	-2	39	18	36

Table 2. (Continued)

Period	1960 -61	1961 -62	1962 -63	1963 -64	1964 -65	1965 -66	1966 -67	1967 -68	1968 -69	1969 -70	1970 -71	Av.
	langleys per day											
Oct 4-10	83	36	49	11	-1	29	-5	18	15	-19	40	23
Oct 11-17	-2	47	7	-1	12	-27	-12	-5	-32	-50	9	-6
Oct 18-24	-20	-2	-18	26	-31	-27	-43	-20	-57	-47	-35	-25
Oct 25-31	15	3	-25	-75	-49	-27	-29	-7	-51	-33	-14	-26
Nov 1-7	-6	-46	-34	-66	-36	-58	-26	-30	-51	-43	-51	-41
Nov 8-14	-39	-40	-75	-78	-51	-36	-76	-30	-47	-80	-121	-61
Nov 15-21	-4	-36	-69	-120	-17	-45	-49	-25	-69	-68	-49	-50
Nov 22-28	-33	-47	-70	-114	-97	-32	-45	-46	-47	-46	-15	-54
Nov 29-Dec 5	-15	-14	-40	-56	-50	-66	-102	-66	-56	-57	-90	-56
Dec 6-12	-4	6	-62	-71	-60	-43	-98	-17	-64	-101	-52	-51
Dec 13-19	-88	-30	-45	-98	-65	-18	-59	-43	-41	-69	-22	-52
Dec 20-26	-53	-102	-67	-103	-99	-77	-55	-79	-38	-96	-38	-73
Dec 27-Jan 2	17	-24	-126	-59	-87	-95	-41	-14	-62	-31	-44	-51
Jan 3-9	-75	0	-32	-48	-82	-65	-31	-22	-68	-106	-58	-53
Jan 10-16	-58	9	-42	-52	-16	-27	-66	-46	-84	-132	-138	-59
Jan 17-23	-39	-6	-14	-79	-55	-29	-83	-28	-37	-48	-84	-46
Jan 24-30	-83	-25	-56	-80	-70	-64	-110	-29	-42	-21	-60	-58
Jan 31-Feb 6	-12	2	-107	-20	-15	-55	-64	-57	-37	-10	-41	-38
Feb 7-13	-14	1	13	-38	-17	-45	-55	-23	-32	-30	-27	-24
Feb 14-20	-32	21	-39	-23	-49	-40	-47	-6	-36	-15	-40	-28
Feb 21-28	-15	-24	-27	-19	-5	-53	-51	-21	-40	1	-58	-18
total												
positive		40,747	40,341	35,798	37,702	31,178	26,159	27,601	28,763	25,270	28,980	32,254
negative		3,031	6,846	8,400	7,021	6,503	9,163	4,585	7,364	8,141	7,259	6,831
net		37,716	33,495	27,398	30,681	24,675	16,996	23,016	21,399	17,129	21,721	25,423

Table 3. SOLAR ENERGY RECEIVED ON A HORIZONTAL SURFACE AT VARIOUS LATITUDES

City	North Latitude	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Av.
		langleys per day												
Miami, FL	25°49'	323	384	468	546	531	485	547	522	435	400	353	326	444
Brownsville, TX	25°55'	258	329	401	486	545	611	633	561	479	411	315	245	440
Apalachicola, FL	29°45'	270	346	435	536	595	593	525	485	455	408	326	262	436
El Paso, TX	31°48'	340	441	556	674	737	735	676	630	552	471	348	300	539
Charleston, SC	32°54'	238	310	418	518	556	527	523	480	424	367	297	236	408
Riverside, CA	33°32'	271	358	468	584	603	629	660	611	505	394	290	258	470
Albuquerque, NM	35°03'	295	379	495	625	702	728	666	619	519	434	310	267	504
Oak Ridge, TN	35°55'	186	244	327	418	503	637	487	443	378	308	199	156	357
Las Vegas, NV	36°05'	287	374	509	632	707	734	673	627	546	436	301	255	507
Davis, CA	38°32'	183	272	418	537	686	712	724	640	502	351	216	153	450
Columbia, MO	38°57'	192	264	344	432	527	558	581	517	403	312	201	174	376
Salt Lake City, UT	40°46'	188	288	427	504	640	676	702	601	497	362	216	163	356
New York, NY	40°46'	155	228	317	400	476	506	495	447	364	269	157	126	329
Cleveland, OH	41°24'	128	191	280	466	494	536	511	453	347	241	121	94	311
Medford, OR	42°22'	119	216	352	475	588	658	696	595	472	290	146	100	358
Ithaca, NY	42°27'	122	202	282	361	465	511	491	423	346	221	103	91	247
Madison, WI	43°05'	184	271	359	411	521	564	572	507	363	262	157	133	294
St. Cloud, MN	45°35'	164	263	361	402	474	532	566	479	349	245	144	113	341
Caribou, ME	46°52'	149	238	466	429	462	517	503	416	315	199	115	108	327
Spokane, WA	47°37'	108	196	319	429	559	628	661	535	401	239	116	76	356
Seattle, WA	47°39'	71	145	243	337	433	504	524	426	316	198	91	59	280
Glasgow, MT	48°11'	154	239	380	434	519	580	635	539	389	260	152	117	367
Goose Bay, Labrador	53°19'	70	160	290	380	440	430	420	330	240	140	80	60	254
Palmer, AK	61°36'	36	87	220	339	422	433	393	307	211	112	43	17	219
Fairbanks, AK	64°51'	17	74	219	378	495	531	477	338	212	85	32	6	239

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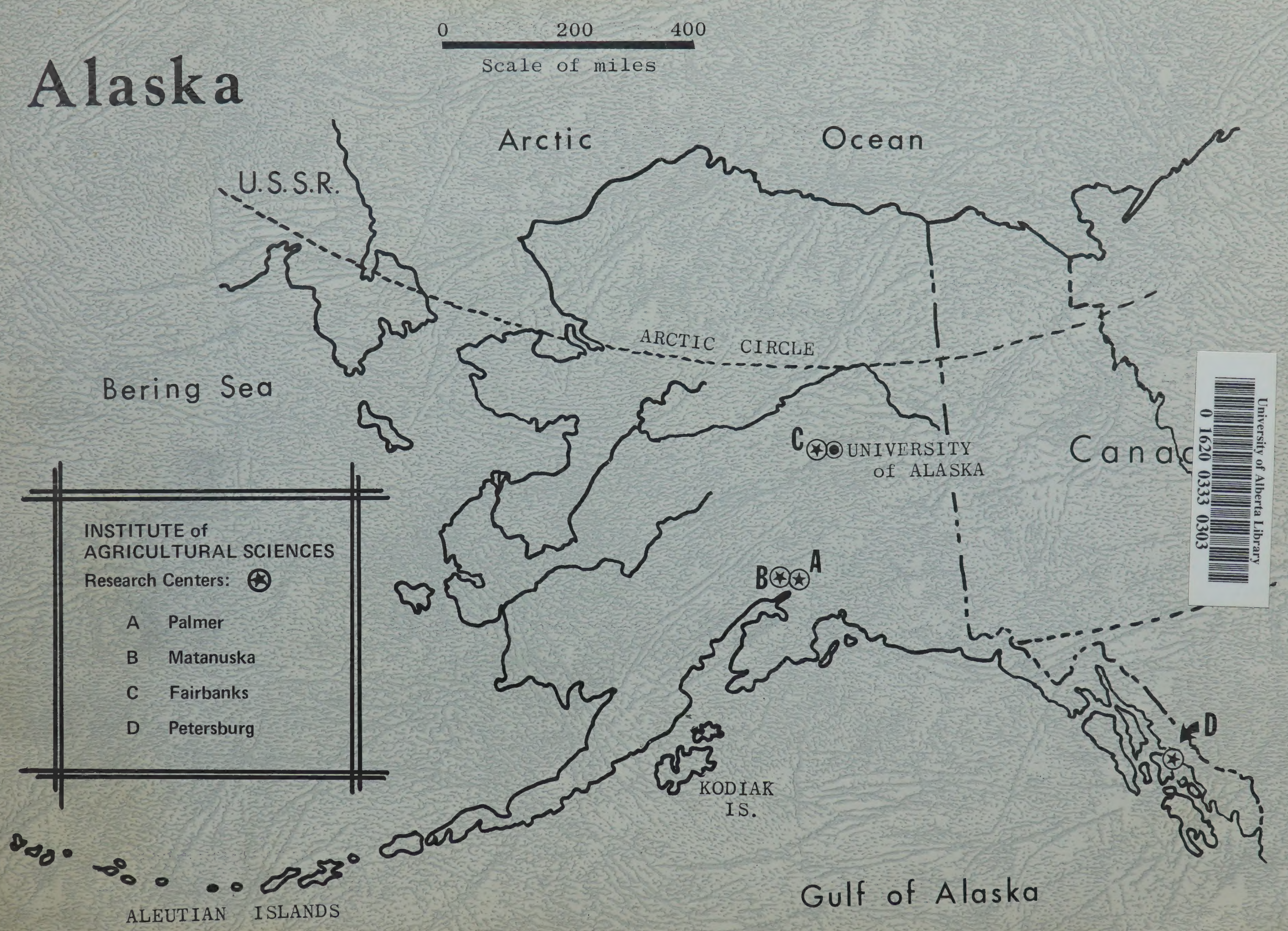
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